Part IV

CLINICAL—ABDOMINAL INFECTIONS
Chapter XVII

PERITONITIS

ETIOLOGY—BACTERIOLOGY

The late Willis Manges, who made many contributions to roentgen diagnosis and therapy, called to our attention several years ago the fact that in the x-ray treatment of gas bacillus infection we had proof of the value of x-rays in treating infections. He pointed out that gas gangrene is an infection which is neither self-limited nor influenced by any other measure and that up to the time x-rays were used in its treatment, recovery was rare without removal of the diseased part. In his opinion, the prompt and consistent action of x-rays in gas bacillus infection established beyond any doubt their status in the treatment of infections.

One may wonder why reference to the use of x-rays in treating gas bacillus infection is associated with the discussion of the use of x-rays in treating acute peritonitis. It is because few are aware of the half-century of controversy in the literature by research men and clinicians concerning the rôle of Bacillus welchii in the etiology of acute peritonitis following appendicitis, intestinal obstruction and other lesions which contaminate the peritoneal cavity with intestinal contents or their bacteria.*

We have stated emphatically that x-ray therapy is the procedure of choice in gas bacillus infection, and in the following pages we hope to present some data on the possible etiologic relationship between this disease and acute spreading peritonitis. This relationship may account for the excellent results we have obtained in treating many cases of acute peritonitis with x-rays.

HISTORICAL

Not many years after peritonitis was determined to be infectious in origin, Welch² published the first report on the anaerobic group of organisms. Shortly after this, Welch and Flexner³ (1892-1896) found Clostridium welchii in severe cases of acute peritonitis due to contamination with intestinal bacteria.
peritonitis. Veillon and Zuber\(^1\) in 1898 thought the anaerobes were the most important organisms in appendicitis and also reported that they had demonstrated an anaerobic coccus. Thus started the long procession of investigations into the bacteriology of this common appendical complication.

Before the turn of the century the claim that Cl. welchii was a factor in peritonitis had some supporters. Many others, however, were more inclusive in their claims and, like Veillon and Zuber, stated that the infection was due to multiple organisms and that anaerobic cocci as well as bacilli were present in appendicitis and some forms of peritonitis.

The position of Cl. welchii as a factor in peritonitis has been energetically maintained since that time by certain workers both in this country and abroad. Some were especially interested after the production of anti-gas serum during World War I. Many, including Williams,\(^5\) Michel\(^6\) and Bower,\(^7\) attempted to lower the mortality of peritonitis by the use of anti-gas serum. Whether or not they succeeded in their primary purpose is not of great interest, but their study of the disease and their observations on its local and general aspects have been of great value.

Williams, after drawing attention to the marked similarity of the general clinical manifestations of cases of acute spreading peritonitis and acute obstruction, observed a striking resemblance of the toxemia of acute peritonitis, acute intestinal obstruction and gas gangrene, describing them as having a characteristic clinical picture different from any other form of toxemia. Williams also referred to a report of the committee on anaerobic bacteria and infections published by the Medical Research Council (British) concerning the clinical aspects of this anaerobic toxemia resulting from war wounds. He considered this description applicable to the terminal stages of peritonitis.

Williams' article is most instructive. It contains data on the bacteriology of peritonitis and some important observations on the effect of the toxemia on the heart muscle and liver of patients dying of the disease. He contended that these changes are compatible with Cl. welchii toxemia, as they are comparable to the changes found in dogs dying of peritonitis produced experimentally. Williams was inclined to believe that absorption of the toxin from the intestinal contents of the obstructed bowel, whether organic or paralytic, was the source of the toxemia. But
from the current literature, one has the impression that absorption from the peritoneal surface after peritonitis is established is a much more likely route of entrance for the toxin. The toxin, according to some workers, is apparently not absorbed from within the bowel, but there is a general agreement that toxin is absorbed readily from the peritoneal surface.

Michel in 1926 reported the use of polyvalent gas antitoxin with apparent success in cases of gangrenous appendicitis. This work was based on the bacteriologic studies of Veillon and Zuber and of Weinberg and Prévot who found the anaerobes in appendicitis and peritonitis with Clostridium welchii in very many cases.

A prominent investigator in this country is Bower of Philadelphia. He and others have been able to obtain a lower mortality in their peritonitis cases treated with Clostridium welchii serum than in their cases receiving no serum. That the mortality rate is not lower is probably due, as in gas bacillus infection, to the difficulty of neutralizing with any one stock antitoxin all the toxins produced by the several organisms present in this mixed infection.

One of the most carefully prepared reports on the bacteriology of acute peritonitis comes from Altemeier of the Henry Ford Hospital, Detroit, where, with McClure, Hartman, Allen, Doub, Jones and others, this subject has been closely studied during recent years.

As an introduction to his report, Altemeier abstracted important contributions to the subject of the past 50 years. From this review and from Altemeier's report, it is evident that a mixed infection usually containing three or more anaerobes growing in symbiosis may, with fair certainty, be stated to be the usual cause of peritonitis following appendicitis. Clostridium welchii is present, but not as often as some of the other organisms. Altemeier indicated the great difficulty of designating with accuracy the rôle of each organism in the pathogenesis of this infection.

Altemeier listed many reports in the literature, among them reports minimizing the importance of Clostridium welchii, but the majority agree that a variety of anaerobes is present. Altemeier and his colleagues agree with this conclusion. The following quotations from Altemeier's article show that this is truly a complex problem.
Members of the Clostridium group were recovered in only 13.5 per cent of the cases. This was quite surprising in view of the frequent reports of the prevalence of members of this group, especially Cl. welchii, in acute appendicitis peritonitis.

In considering the total number of different species of both aerobic and anaerobic micro-organisms found in the peritonitis exudate, it is found that three or more species were recovered from 96 of the 100 cases and five or more in 50 of the cases. Every peritonitis exudate which was investigated bacteriologically yielded at least one bacterium, and in no instances was an entirely negative culture obtained. The average number of species per case was 4.28.

These findings show the bacterial flora of peritonitis secondary to acute perforated appendicitis to be more complex and bizarre than previously believed.

In comparing the flora of the fatal and non-fatal cases, little difference is found in the type of species present. The B. coli, B. melanogenicum, and anaerobic streptococci were recovered from each of the six fatal cases.

Wishing to determine whether or not the numerous bacteria were present in only the immediate peritoneal exudate or in the delayed secondary and metastatic abscesses as well, the flora of all such complicating abscesses was also investigated.

Comparing the flora of the original peritoneal exudate culture with that of its secondary and metastatic abscess complications, we found essentially the same organisms in each instance. It was of particular interest to note the almost identical flora of an appendiceal abscess as compared with a metastatic brain abscess developing six weeks after operation. These findings indicate that the peritonitis resulting from a perforated appendix, and its purulent complications as well, are mixed infections, and are not due to single organisms.

Essentially the same organisms can be isolated from associated secondary and metastatic abscesses in remote areas of the body.

Consequently, any perforative lesion in the region of the appendix or cecum must necessarily result in contamination of the peritoneal cavity by a large number and variety of organisms resident in that region of the intestine at the time of perforation. That many of these bacteria grow prolifically within the peritoneal cavity has been proved. When cultured, these organisms grow best in close association or symbiosis with each other.

The more clinically severe cases of acute perforated appendicitis occurred most frequently in those cases having five or more infecting micro-organisms. No case from which only one Bacterium was recovered terminated fatally.

The presence of B. melanogenicum, which was found in 92.7 per cent of the cases, is described for the first time, to the best of our present knowledge, in appendicitis peritonitis. The frequent association of the B. melanogenicum and anaerobic streptococci is emphasized.

Gins, in 1934, made the only reference to the B. melanogenicum,
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occurring in appendicitis, which we have been able to find.

Of almost equal interest is the presence of anaerobic streptococci in 64 cases (66.6 per cent of the positive anaerobic cultures). These streptococci in almost every instance grew in close symbiosis with the B. melanogenium, and were separated from the latter with extreme difficulty. Anaerobic streptococci have been previously described in peritonitis by Veillon and Zuber, Ruenberg, Heyde, Brutt, Weinberg, et al., Friederich, Hudaesek and Kerbler, Gins, McDonald, Henthorne, and Thompson.9

Early in our experiences with gas bacillus infection, we were impressed with the difficulty of drawing fine conclusions about the exact rôle of the many organisms involved in that infection. We feel exactly the same way about the organisms involved in peritonitis. The bacteriology is intricate and complicated and requires further investigation. But the fact remains that in many respects the two diseases are similar, especially in their prompt response to x-ray therapy.

From a clinical standpoint the two diseases are strikingly similar in appearance, course and results. Both are acute rapid-

<table>
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<th>TABLE 21</th>
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**Comparison of Gas Bacillus Infection and Appendicitis-Peritonitis**

<table>
<thead>
<tr>
<th>Gas Bacillus Infection (Gas gangrene)</th>
<th>Acute Spreading Peritonitis (Appendicitis-peritonitis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known as a separate entity through the work of Welch and his colleagues, who investigated the anaerobic organisms between 1892 and 1900, when Cl. welchii was isolated and identified. Cl. welchii has been recognized since the time of Welch's investigation as one of the principal organisms found in gas bacillus infection.</td>
<td>In 1896 Welch and Flexner found Cl. welchii in the flora of acute peritonitis. Many have maintained since 1896 that Cl. welchii is one of the principal organisms of acute spreading peritonitis. They base their contention on the fact that Cl. welchii is frequently found in bacterial studies of peritonitis.</td>
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</table>

ly spreading infections with a fulminating course. Both are caused by a variety of organisms growing in symbiosis. Anaerobes, including some anaerobic cocci, are found in both diseases. General symptoms are those of severe toxemia, often out of proportion to the local involvement. Locally, gangrene often develops if the case is allowed to progress (appendix—gallbladder). In both, gas is produced at the site of infection. Both give rise to changes in principal organs because of toxin absorption. Both have responded variably to Cl. welchii serum. Both dis-
disease. With peritonitis, as with gas bacillus infection, there is no difficulty in reaching agreement as to satisfactory diagnostic criteria of the advanced stages; but early-stage criteria satisfactory to one physician may be entirely unacceptable to another.

TABLE 22

CLINICAL STAGES OF ACUTE SPREADING PERITONITIS

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>First stage</td>
<td>Appendicitis.</td>
</tr>
<tr>
<td>Second stage</td>
<td>Appendicitis plus localized peritonitis, which may go through all stages to abscess formation.</td>
</tr>
<tr>
<td>Third stage</td>
<td>Early spreading peritonitis; serosanguineous stage with blood and serum in the peritoneal cavity and over the loops of bowel, probably with a small amount of pus. No adhesions, since the serum has not yet coagulated and formed fibrinous bands between the various loops of bowels.</td>
</tr>
<tr>
<td>Fourth stage</td>
<td>The fibrinopurulent stage. The bloody feature is disappearing; the serum is becoming fibrinous and thicker, is forming bands between loops of bowels; some pus is accumulating.</td>
</tr>
<tr>
<td>Fifth stage</td>
<td>Many adhesions are present which are more or less organized, and there is a profuse collection of pus with probably some localized abscesses from time to time.</td>
</tr>
</tbody>
</table>

It is essential that general peritonitis be differentiated from the common local peritonitis which usually gives no trouble after the appendix is removed. Even with the abdomen open there is often disagreement as to whether early generalized peritonitis is present; after the abdomen is closed, there is almost no chance of agreement among the consultants that general peritonitis is present until the process is well advanced.

Because x-rays when given early usually cause prompt subsidence of peritonitis symptoms, lack of agreement as to what is early general peritonitis makes it somewhat difficult to judge the matter from a statistical standpoint. There may be criticism regarding the accuracy of diagnosis in some cases of acute peritonitis which we have treated. Further study in relation to x-ray therapy will establish more definite criteria.

PROGNOSIS

In treating a case of gas bacillus infection with x-rays, one may count with considerable consistency on a given result in a given type of case. Although our experience with acute, spreading peritonitis has been much less extensive than with gas

*For a discussion of the necessity for correct diagnosis see page 277.
bacillus infection, we have found about the same type of response to x-ray therapy in both diseases. The promptness and certainty of the result depend on the stage of the disease at the time treatment is started. If x-ray therapy is started during the early stages of the bacterial invasion, when the peritonitis is in the serosanguineous stage or before (Case 30), the response is more prompt than when treatment is started later in the fibrinopurulent stage (Case 36, p. 267). It is desirable to prevent the invasive stage of the disease from reaching the deeper layers of the peritoneal surface, and, thereby, to lessen the tendency to formation of fibrinous bands and pus pockets in the peritoneal cavity.

The object of early treatment is to turn back the fast-growing invaders in the hope that the more stubborn, slowly growing organisms will fail to establish a growth. We have all seen the occasional patient whose postoperative condition seemed to justify a favorable prognosis suddenly make an unexplained turn for the worse, have a stormy course and even die. When these patients eventually recover, as they often do without the aid of the x-ray, their convalescence is usually prolonged and some long-standing partial disability may result which might have been prevented by more prompt x-ray treatment. Since the x-ray technic recommended is so harmless and yet so effective, it seems good practice to treat even the patient with a good prognosis. Certainly all patients for whom there is any doubt about the postoperative course should be given x-ray treatments. With a mobile unit, this is simple, harmless and easy for the surgeon as well as the patient.

If abscess formation is present at the time of operation or if x-ray treatment is not started until the third to the fifth day postoperative course should be given x-ray treatments. With a valescence is less certain because the tendency to formation of multiple fibrinous adhesions and a suppurative process at this time is much greater than if treatment is started earlier in the disease. Therefore irradiation in a late stage meets with a slow response, because it is necessary to drain the abscess pockets by surgical measures. Each surgical procedure should be followed immediately by one or two x-ray treatments to prevent, if possible, further spread of the infection.
VARIOUS STAGES—PATHOLOGY AND TREATMENT

FIRST STAGE.—Appendicitis.

Pathology.—The inflammation is still confined to the appendix.

Treatment.—Some may attempt to use x-rays and omit surgery in the treatment of the various stages of appendicitis, but this condition is strictly surgical, and use of x-rays is indicated only as an aid in localizing the infection to the peritoneum immediately adjacent to the appendix. If surgery is contraindicated or not available, no harm would come from a few x-ray treatments. In fact they would be indicated, but only under exceptional circumstances should x-rays be substituted for surgery in acute appendicitis.

One or two x-ray treatments may be given preoperatively to lessen the chances of peritoneal extension (or peritonitis) and a treatment or two after appendectomy is recommended for the same reason. Some may elect to use this procedure, but surgical removal of the appendix is indicated for acute appendicitis whether or not x-ray treatments are given.

SECOND STAGE.—Appendicitis plus localized peritonitis.

Pathology.—Inflammation now involves the adjacent peritoneum and may terminate in a localized abscess requiring drainage.

Treatment.—In the first and second stages, x-ray treatment may be said to be given for prophylaxis, because the conditions in these stages in themselves have little or no mortality; if one were not interested in preventing generalized peritonitis, with its high mortality, these conditions which are often the early stages of generalized peritonitis would not be mentioned as probable subjects for x-ray treatment. To prevent acute, spreading peritonitis before or after appendectomy with or without any degree of peritonitis, x-rays are useful, but they are recommended as an aid to surgery, not a substitute for it.

X-ray therapy will be helpful to the surgeon who prefers to operate after the acute phase of appendicitis has passed and the local reaction has subsided. From our clinical experience and experimental work with dogs, it seems certain that x-rays can be relied on to localize the infection before operation. Surgical exploration of the lower part of the abdomen and the pelvis in itself has practically no mortality. Therefore, after the infection
is controlled, surgery is always indicated, lest some dangerous focus be left around the diseased appendix.

**Third Stage.**—Early, acute, spreading peritonitis.

*Pathology.*—This is the serosanguineous stage, usually involving the entire peritoneum.

A case of early spreading peritonitis started our work with peritonitis. This is the stage in which the most spectacular results were obtained. It is the most responsive, because the infection has not produced such extensive local changes as to interfere with prompt recovery. It is the earliest stage in which general peritonitis is definitely present clinically.

*Treatment.*—X-rays should be administered twice or three times the first day, twice the second and third days and, thereafter, 25 to 50 r units daily until the patient is definitely out of danger. In this stage, the mortality rate without x-ray treatment is between 40 and 50 per cent. X-ray therapy of gas bacillus infection has lowered the mortality to 10 per cent or less. What has been said concerning early and frequent treatment of gas bacillus infection can be repeated here word for word. We venture the prophecy that an honestly observed series of cases of acute peritonitis treated with x-rays will show a mortality of not more than 5 to 8 per cent in this stage.

**Fourth Stage.**—Fibrinopurulent stage.

*Pathology.*—The disease is more advanced than in the third stage, with a large amount of free pus and some recently formed adhesions.

Some prompt recoveries have been witnessed, but the response is usually slower and the chance of avoiding other complications is less than in the previous stages. Considerable toxemia is present, and x-rays should be used to control this feature of the disease, but the chances for a prolonged convalescence are increased with every day of delay of x-ray therapy.

*Treatment.*—Two or three treatments each day are indicated until the toxemia is controlled.

**Fifth Stage.**—Adhesions and abscesses.

*Pathology.*—In this stage there is not much chance for shortening the course by giving x-ray treatments, nor are x-rays as important unless the toxemia is not yet under control. When the disease is this far advanced, a long period of hospitalization is inevitable. If secondary operations are necessary, a dose or two
of x-rays or even a two to three day series may be required to localize the process again. Also, when local extension or increased toxemia becomes evident in this stage, x-ray treatment should be used.

Treatment.—If treatment is desired, two treatments each day for two or three days and others later as indicated may be valuable in the exceptional case, but as a rule it is too late to shorten the course.

TREATMENT

The etiologic rôle of Cl. welchii is not important as far as the choice of therapy is concerned. Regardless of whether Cl. welchii is or is not the most important etiologic factor in acute, spreading peritonitis secondary to appendicitis, it is certain that the anaerobes are a factor. Judging from the effect of x-rays in gas bacillus infection, x-ray should be the treatment of choice for other infections with anaerobic gas-forming organisms and therefore appropriate in acute, spreading peritonitis secondary to appendicitis and other sources of intestinal contamination.

Our clinical experience in the treatment of acute peritonitis with x-rays is confined to the past six years and, for many reasons, final conclusions about any phase of the subject cannot be made. Time and the experience of many workers will produce the data on which to base final conclusions. As in gas bacillus infection, so too in acute spreading peritonitis, x-rays have a favorable influence on all the clinical signs and symptoms.

TECHNICAL ASPECTS OF TREATMENT

It will be seen that the x-ray technic used in the peritonitis cases reported below is similar to that used in the treatment of gas bacillus infection involving the trunk. And, as in gas bacillus infection, we believe that x-rays may be used in both the prevention and the treatment of spreading peritonitis caused by contamination with organisms from the bowel.

The technical factors given in Table 23 may serve as a general guide in the treatment of peritonitis. The technic used in each case has been included in the history and should be of some assistance. A review of the detailed comment (pp. 218-224) on each of the dosage factors indicated for gas bacillus infection may clarify Table 23. If there is remaining difficulty regarding
dosage, the complete discussion of dosage factors in Part I should be consulted.

Small girls and pregnant women should be given x-ray treatments with caution, and large doses should be avoided unless the condition of the patient is critical enough to warrant such doses.

### TABLE 23

**X-Ray Dosage in Peritonitis**

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>1st and 2d Stages</th>
<th>3d Stage</th>
<th>4th Stage</th>
<th>5th Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter</strong></td>
<td>1-5 mm. Al or 0.25 mm. Cu and 1 mm. Al</td>
<td>1-5 mm. Al or 0.25 mm. Cu and 1 mm. Al</td>
<td>1-5 mm. Al or 0.25 mm. Cu and 1 mm. Al</td>
<td>1-5 mm. Al or 0.25 mm. Cu and 1 mm. Al</td>
</tr>
<tr>
<td><strong>Kilovoltage</strong></td>
<td>100-135 kv.</td>
<td>100-135 kv.</td>
<td>100-135 kv.</td>
<td>100-135 kv.</td>
</tr>
<tr>
<td><strong>Distance</strong></td>
<td>40 cm.</td>
<td>40 cm.</td>
<td>40 cm.</td>
<td>40 cm.</td>
</tr>
<tr>
<td><strong>Size of port</strong></td>
<td>20 x 30 cm.</td>
<td>20 x 30 cm.</td>
<td>20 x 30 cm.</td>
<td>20 x 30 cm.</td>
</tr>
<tr>
<td><strong>r units per dose</strong></td>
<td>60-80 r</td>
<td>60-80 r</td>
<td>60-80 r</td>
<td>50-70 r</td>
</tr>
<tr>
<td><strong>Space factor</strong></td>
<td>1 daily for 5 da.</td>
<td>2-3 daily for 3-4 da.</td>
<td>2-3 daily for 3-4 da.</td>
<td>2 daily for 2-5 da.</td>
</tr>
<tr>
<td><strong>Estimate of total dose in 3-5 da.</strong></td>
<td>180-240 r</td>
<td>360 r</td>
<td>360 r</td>
<td>240 (estimate)</td>
</tr>
<tr>
<td><strong>Maximum intensity factor</strong></td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>60%</td>
</tr>
<tr>
<td><strong>Loss factor</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Minimum intensity factor</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* To include the entire abdomen, as it is better to include too much tissue than to miss some infected tissue.

† After 500 r has been put through any port in three days or less, reduce to 25 r per dose and give one dose daily through each port unless urgent.

This discussion is concerned with the use of x-rays in the prevention and treatment of peritonitis, but it must be understood that all other commonly employed measures have also been used even though we have not mentioned their rôle in each in-
stance. Among these measures are the oxygen tent, the Wangen­
steen suction apparatus, the Miller-Abbott tube, transfusions and
various solutions and drugs given intravenously and otherwise
with the exception of sulfanilamide and its early derivatives.
We have had no experience treating patients for whom the
sulfonamides have been used locally, as in the peritoneal cavity.
Our conclusions have been based on cases in which the sulfona­
mides were given internally. Therefore, x-ray therapy is the
only feature of the treatment which we discuss in detail, con­
sidering it always as only one of the measures essential to suc­
cessful treatment.

The most important factor in x-ray therapy is the stage of
the disease in which it is started. X-ray treatment is therefore
discussed on that basis.

The value of early treatment of appendicitis-peritonitis can­
not be overemphasized. When x-ray treatment is given early,
during the acute, spreading, serosanguineous phase, the condition
responds promptly and completely, seeming to undergo thorough
resolution without complications. But, when treatment is started
late, during the stage of plastic peritonitis with pus formation,
there is much more difficulty in controlling the situation and in
obtaining prompt recovery. Invariably, convalescence is pro­
longed and is associated with the discharge of large amounts of
pus and with pocket formation. Repeated surgical intervention
may be necessary before the patient is safely convalescent. We
have yet to treat a patient in the early stage who died of the
peritonitis. No patient treated early with x-rays died during
the fourth to the sixth day, or before, of the acute toxemia of
peritonitis.

Second Stage

Case 26.—P. W., a girl aged 10, was admitted to the hospital on
July 13, 1938, with history of pain in the lower right quadrant for
36 hours. Examination revealed extreme tenderness over the appendix
and in the epigastrium and considerable abdominal rigidity. At opera­
tion at 11:00 P. M., the appendix was found wrapped in the omentum
with a small amount of free pus in the abdomen. The patient received
one x-ray treatment on each of the four following days. The only
other therapy was a dose of milk of magnesia the day before leaving the
hospital on July 24. This patient was treated early and the response
was prompt. The pulse rate and temperature were at no time alarm­
ing (Fig. 56).
Many youngsters respond so promptly that one is uncertain whether or not they would have done just as well without x-ray therapy. The fact that this patient went home 10 days after operation for a severe attack of appendicitis is probably of some significance, especially after free pus was found in the peritoneal cavity. Doubt as to the necessity for x-ray therapy in pneumonia, mastoiditis and other acute infections in children often has arisen because of their prompt response. This is especially true when x-ray therapy is instituted early.
Since it is important to treat early in gas bacillus infection, it is fair to assume that it is important to treat early for appendicitis-peritonitis or postoperative peritonitis, even at a time when it is doubtful that peritonitis is present (see Case 38).

Third Stage

CASE 27.—M. K., a girl aged 16, was admitted to the hospital July 12, 1934, with a diagnosis of acute appendicitis. The white blood cell count was 19,400, with 69 per cent polymorphonuclear leukocytes. She was operated on immediately. The appendix was greatly distended, gangrenous at the tip, and there was free fluid in the peritoneal cavity. The following day a diagnosis of general peritonitis was made, and x-ray treatment was started immediately. The patient received one treatment the first day, two on each of the following two days and one the fourth day. Response was prompt (Fig. 57), and she left the hospital the eighth postoperative day.

Three features in this case are worthy of note: x-ray treatment was started the day after operation; the incision healed by primary intention, and the patient left the hospital the eighth postoperative day. The suction apparatus and sulfanilamide were not used. This patient left the hospital as soon as patients do who have no peritonitis.

CASE 28.—R. P., a boy aged 2½, was admitted to the hospital with a history of generalized abdominal pain of 48 hours' duration. He was operated on immediately, and a ruptured, gangrenous appendix with a partially localized peritonitis was found. The pathologist's report was acute diffuse appendicitis. White blood cell count at the time of operation was 15,800, with 91 per cent polymorphonuclear leukocytes.

X-ray therapy was started eight hours postoperatively. Two treatments were given daily for three days, and four more treatments were given in the ensuing five days. The temperature varied irregularly from 99 to 102 F. It was 102.2 F. the first postoperative day. Temperature was not normal until the tenth postoperative day, but the patient was never desperately ill, and whereas convalescence was somewhat stormy for the first few days, it was never a matter of serious worry to the surgeon (Fig. 58, p. 256). Other treatment included fluids intravenously, opiates and carbon dioxide inhalations.

CASE 29.—T. B., a man aged 30, entered the hospital May 16, 1941, with a history of pain, nausea and vomiting of three days' duration. Immediate operation revealed a retrocecal, gangrenous appendix and some clear fluid in the abdomen.

X-ray therapy was started immediately postoperatively, and two treatments were given daily for two days and one daily for four days. Convalescence was uneventful. The only medicaments given were
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opiates and prostigmin. The suction tube was used for eight days. The patient was dismissed the twenty-second postoperative day.

This patient was in a serious condition at the time of operation. The surgeon who operated on him was thoroughly impressed

with the value of x-rays in minimizing the seriousness of peritonitis after their use in this case. Case 39, another from the same surgical service, gave added confidence to this surgeon.

CASE 30.—T. O. B., a man aged 22, was admitted to the hospital February 7, 1938, with a diagnosis of appendicitis. The white blood

FIG. 57.—Case 27. Generalized peritonitis following acute appendicitis. Drop in pulse rate is typical of cases receiving early x-ray therapy. Technical factors were: 110 kv.; 5 ma.; 50 cm. distance; 2 mm. Al filter; anterior abdomen as port. Result was excellent.
cell count was 18,300, with 79 per cent polymorphonuclear leukocytes. Immediate operation revealed a retrocecal appendix, acutely inflamed, perforated at the tip, and bloody fluid and free pus in the peritoneal cavity. The patient was given an x-ray treatment two hours after operation (at 7:30 p.m.), two treatments on each of the following three days and one on the last day. There was prompt clinical improvement, and at no time did the patient show the postoperative evi-
patients were treated before and others immediately after operation, with no apparent effect on the operative wound.

Case 31.—F. B., a man aged 57, entered the hospital with a history of severe epigastric pain for 30 hours. He had a long history of chronic dyspepsia. When admitted, he had been comatose for eight hours and the abdomen was rigid. A tentative diagnosis of perforated peptic ulcer was made, but an x-ray film failed to show evidence of free gas in the peritoneal cavity. The diaphragms were high and both
lungs were congested at the bases. A laparotomy disclosed a perforated gangrenous gallbladder with diffuse peritonitis. X-ray therapy was started the second postoperative day, at which time the condition appeared very serious. Five treatments of 75 r each were given in

<table>
<thead>
<tr>
<th>MONTH</th>
<th>August</th>
<th>August</th>
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</tr>
<tr>
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Fig. 60.—Case 31. The prompt drop of temperature in this patient with gangrenous perforated gallbladder is similar to the drop witnessed in gas bacillus infection on many occasions. Peritonitis following ruptured gallbladder is usually a serious condition, but this patient made a prompt recovery. Technical factors were: 110 kv.; 5 ma.; 40 cm. distance; 3 mm. Al filter; anterior abdomen as port. Result was excellent.

three days. He also received 90 cc. of prontosil during the first five postoperative days. He made a very remarkable recovery (see Fig. 60).

This case is unusual in our series, as it is the only one of perforated gallbladder complicated by general peritonitis which
we had an opportunity to treat. Certainly, the patient with acute cholecystitis who is too ill for immediate operation should have two or three x-ray treatments each 24 hours with the hope of localizing the pathology and minimizing the toxemia. Pre- and postoperative radiation therapy is indicated in such cases.

Fourth Stage

Case 32.—R. L., a boy aged 10, entered the hospital March 3, 1939, with a history of having been confined to bed for one week with a condition diagnosed as influenza, characterized by fever, cough and malaise. Four days prior to admission, abdominal pain had developed.
and he had been nauseated, vomiting frequently. On admission, the white blood cell count was 14,650, with 87 per cent polymorphonuclear leukocytes, temperature 102.6 F., pulse rate 120 and respiratory rate 30. An appendectomy done immediately revealed a perforated appendix with a large localized abscess well down in the pelvis. Pus was evacuated with a suction apparatus and the appendix removed. Two soft rubber drains were inserted. The pathologic report was: “thick-walled appendix; ulcerated mucous membrane; necrotic wall.” Pathologic diagnosis was: “acute, gangrenous appendicitis with perforation.”

X-ray therapy was started immediately after operation, with one treatment on the first day, two on each of the next two days and three during the last five days (Fig. 61).

Convalescence was uncomfortable because of persistent cough, but it was otherwise uneventful. The patient was dismissed from the hospital on the fifteenth postoperative day.

**Case 33.** G. M., a woman aged 36, was admitted to the hospital...
Peritonitis

October 30, 1938, with a history of severe abdominal pain of five days' duration and nausea and vomiting of two days' duration. The abdomen was rigid throughout and exceedingly tender, especially in the lower right quadrant. Laparotomy done three hours after admission revealed generalized peritonitis. No attempt was made to remove the appendix. Three drains were inserted and the wound was closed. X-ray therapy was instituted the second postoperative day and continued for the next five days for a total of seven treatments. The other principal therapeutic measures included opiates, fluids intravenously and use of the suction apparatus, the last started immediately after operation.

The patient made a fairly steady recovery, and convalescence was uneventful except for toxemia during the first three days she received x-ray therapy (Fig. 62). There is a distinct advantage in instituting treatment in this type of case immediately after return from the operating room and not delaying therapy until the second postoperative day, as was done here.

The disease was too far advanced at the time of the operation for recovery without some anxious days. The patient left the hospital the twentieth postoperative day, which should be considered a rapid convalescence in view of the severity of the disease.

The appendix was not removed during the first operation because of the patient's poor condition. She returned six months later complaining of pain in the lower right quadrant of one week's duration. The temperature was 98.2°F., pulse rate 72 and respiratory rate 18. The white blood cell count was 5,700, with 63 per cent polymorphonuclear leukocytes. Operation revealed dense adhesions in the abdomen and pelvis caused by the previously ruptured appendix. The appendix had ruptured in the midportion and part of it had sloughed out, leaving a distal inch and a proximal inch which had healed over. Recovery was uneventful after the second operation, and the patient was dismissed after 11 days in the hospital. She received no x-ray therapy during her second stay at the hospital.

Fifth Stage

Those who have their first experience in the x-ray treatment of peritonitis in this late stage will be greatly discouraged, just as others are disappointed who try all other methods of therapy for gas bacillus infection until the patient is moribund and then expect x-rays to save the patient.

In the late stage of peritonitis, one can look for all the trouble encountered in the late stages of gas bacillus infection. To appreciate the advantages of early treatment in peritonitis, the reader is referred to the statistics on mortality of gas bacillus infection according to the number of treatments given (Fig. 50 and discussion, p. 224 ff.).
The fifth stage is comprised of the neglected patients with appendicitis who have a palpable abscess when diagnosis is made. This type of patient may well be operated on as soon as the abscess is localized. After drainage is established, prophylactic radiation is indicated to minimize the danger of extension of the infection after the necessary surgical manipulations.

Many patients in whom treatment is necessarily started late, i.e., after fibrinous bands and purulent collections are formed, require secondary operation for drainage of some of the pus-filled areas. In our series all deaths occurred in the group with adhesions and multiple pockets of pus. We have had no deaths during the acute, invasive, toxic phase of generalized peritonitis. All patients treated with x-rays survived this stage, but in some the secondary abscesses which formed and required drain-
age were too extensive and the patients eventually died. The abscesses were in the left lower quadrant, right lower quadrant, subhepatic, subphrenic and pulmonary regions; those in the last-mentioned areas probably were not direct extensions but were due to infarction.

**CASE 34.**—V. B., a girl aged 9, was admitted to the hospital July 4, 1938, with a history of nausea, vomiting and severe and persistent ab-


<table>
<thead>
<tr>
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<th>Amp.</th>
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<th>Angle</th>
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<td>920</td>
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</table>

**FIG. 64.**—Case 35. Daily record of dosage factors used. It shows two distinct series of treatments with an interval of one week.

dominal pain of two weeks' duration. On admission there was a palpable mass in the lower right quadrant. The white blood cell count was 16,300, with 85 per cent polymorphonuclear leukocytes. Operation two hours after admission revealed a retrocecal appendix, firmly bound down, with the distal third sloughed off. The process had become localized and formed an abscess containing thick, yellow, odorless pus. The cecum was markedly inflamed and exceedingly friable; the whole mass was covered by a loop of ileum. Two Penrose drains were inserted.
The wound drained profusely, and the temperature ran a septic course, varying from normal to 102.8 F. On the thirteenth postoperative day the surgeon requested x-ray therapy, and one treatment was given daily for five days. The patient's condition improved rapidly (Fig. 63), and she was dismissed the twentieth postoperative day in good condition. Other postoperative treatment was entirely symptomatic. Chemotherapy was not used.

Case 35.—S. V., a boy aged 16, entered the hospital January 15, 1940, at 11:45 P.M., with a history of pain in the lower right quadrant for two days and nausea and vomiting for one day. The entire abdomen was rigid. The white blood cell count was 14,350; differential count was not made. Temperature was 103.4 F., pulse rate 130 and respiratory rate 26. Immediate operation disclosed acute appendicitis

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**Fig. 65.**—Same case as preceding. The black line indicates the percentage given each day; the loss between treatments is indicated by the downward direction of the same line. The maximum point of tissue saturation is about 75 per cent. There was no constant minimum saturation.
with perforation and generalized peritonitis with no attempt at localization.

X-ray treatment was given as follows (Figs. 64 and 65):

<table>
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<tr>
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<tr>
<td>1-16-40</td>
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<tr>
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<td>2 treatments</td>
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</tr>
<tr>
<td>1-23-40</td>
<td>1 treatment</td>
</tr>
</tbody>
</table>

Convalescence was not particularly stormy until the seventh postoperative day, when the patient began to show evidence of obstruction. He was given an enema and pituitrin on January 23 but without much effect. The following day x-ray films showed evidences of obstruction of the small bowel. He was given pitressin and managed to expel some gas. He was also given an x-ray treatment and was apparently somewhat improved. However, a pelvic abscess formed and drainage was
necessary a week later, February 1, when a large quantity of pus was found in the pelvis and abdomen. About 1 qt. of pus was evacuated and two drainage tubes were inserted. Drainage was profuse and the temperature reached 102.8 F. A second series of x-ray treatments was given and he was dismissed February 13, although there were still considerable drainage from the wound and some pain in the left lower quadrant. Additional therapy consisted of suction apparatus, fluids intravenously and sedatives. This boy received two complete series of x-ray treatments.

Figures 64 and 65, showing the several x-ray treatments given in two distinct series with a week intervening and their entry on the saturation chart in graph form, are presented because repetition of the entire series was unusual. It is occasionally necessary to give a treatment or two a few days after the first series has been completed, but in this case practically a full series was repeated. Maximum saturation was about 75 per cent.
Both types of records should be kept for all cases. The detailed report is essential, and the loss graph is important if many treatments are given through one port. The necessity for irregular short periods of treatment is common if patients are not treated with x-ray therapy until the condition is in the fifth stage.

Case 36.—J. G., a man aged 41, was admitted to the hospital January 21, 1938, with a diagnosis of appendicitis. He was operated on immediately, and a ruptured appendix with general peritonitis was found. He was extremely ill, and the postoperative course was stormy. On the sixth postoperative day, when the condition was considered practically hopeless, the first x-ray treatment was given at 11:30 p.m. Two treatments daily were given on January 28 and 29 and one on January 30 and February 2. Remarkable improvement was noted by this time. Later complications developed in the chest, and late in the evening of February 3, treatment over the chest was started (Fig. 66). Treatments were given each day for the following three days (see Figs. 66 and 67, pp. 265 and 266).

During the 78 day hospital period, this patient had succes-
sively general peritonitis, a subphrenic abscess which ruptured into the pleural cavity and subsequent Type III pneumonia and lung abscess. The suction apparatus, sulfanilamide, oxygen tent and rib resection were used in addition to x-rays. The clinicians felt that recovery was remarkable and were grateful for the help given by the mobile unit at a time when the patient’s condition seemed hopeless.

CASE 37.—D. V., a girl aged 17, was admitted to the hospital November 7, 1937, with the diagnosis of acute ruptured appendix and general peritonitis. The white blood cell count was 26,900, with 95 per cent polymorphonuclear leukocytes. She was too ill for an immediate operation, and was given two x-ray treatments Nov. 9th. The temperature dropped immediately to normal. She was operated on the following morning, and the clinical diagnosis was confirmed. The appendix was not found, but drainage was established. The temperature immediately
rose again to 103 F., and x-ray treatments were resumed, with two treatments given each day for two days and one on each of the following four days. The last three treatments included the lower left side of the chest, as x-ray films showed evidence of pleural involvement (Fig. 68). The peritonitis subsided, and the chest involvement cleared up promptly (Fig. 69). The appendix was finally removed December 22, the forty-second hospital day. This patient had both abdominal and pleural involvement and received pre- and postoperative x-ray treatments (Fig. 70). She was dismissed 95 days after hospitalization.

Patients with peritonitis who are too ill for immediate surgery should have preoperative x-ray therapy. A longer interval than was allowed in Case 37 between the drop in temperature and the surgical intervention seems advisable. Clinical experience has shown that in certain stages general peritonitis does better if allowed to localize before surgery is done. We believe that x-ray therapy is definitely indicated to assist other measures during this period when localization is taking place.
Reactivation of Infection.—One may occasionally be called back to give more treatments if the infection becomes active again. There should be no hesitancy because usually there is prompt response to therapy.

Case 38.—E. S., a boy aged 11, entered the hospital November 10, 1939, with a history of severe abdominal pain, nausea and vomiting of one day's duration. The white blood cell count on admission was 28,870. An operation done immediately disclosed a long appendix perforated at the proximal third and a large amount of foul-smelling fluid in the abdominal cavity, not limited to the appendical area. No adhesions were found. Two Penrose drains were left in place, and x-ray therapy was started with two treatments the first postoperative day.
One treatment was given daily for the following three days. The condition seemed good at this time and therapy was discontinued. X-ray therapy was requested again on the fifteenth postoperative day, when there was evidence of active inflammatory disease in the right side of the abdomen. The consulting surgeon thought that a subphrenic abscess was forming, but x-ray films showed the diaphragm smooth and the base of the right lung clear; there were, however, definite elevation and fixation of the right diaphragm (Fig. 71). X-ray therapy was started, and five treatments were given in the next eight days. Further surgical intervention was not necessary (Fig. 72).

Case 39.—M. A., a woman aged 22, entered the hospital July 17, 1941, with a history of abdominal pain, nausea and vomiting of four days' duration. The white blood cell count was 15,100, temperature
100.4° F., pulse rate 120 and respiratory rate 26. Immediate operation revealed an acute perforated appendix and a small amount of straw-colored fluid in the abdomen. X-ray therapy was started 12 hours after operation, and two treatments were given daily for three days and one treatment daily for two days.

The clinical record (Fig. 73) shows that the temperature and pulse rate remained high for several days after the abdomen was closed without drainage, and during these few days it was thought that early peritonitis was present. What the course might have been had she received no x-ray therapy can only be conjectured, but the attending physician and the attendants from the x-ray therapy section were confident that x-ray therapy aided in hastening the rapid and complete recovery and early dismissal from the hospital.
The Intermediate Case.—Patients who seem to be in little or no danger of developing general peritonitis at the time the appendix is removed may show evidence of increasing infection a few days after operation. As soon as such a condition is suspected or diagnosed, the patient should receive x-ray treatment.

![Graph showing temperature changes over time.]

**Fig. 74.**—Case 40. Patient was apparently well until the sixth postoperative day when the marked rise in temperature indicated infection. She was given four x-ray treatments in two days and the temperature returned to normal. This procedure is easier and safer than a secondary operation to establish drainage. Technical factors were: 120 kv.; 5 ma.; 40 cm. distance; 3 mm. Al filter; anterior abdomen as port. Result was excellent.

**Case 40.**—C. S., a girl aged 13, had an appendectomy on March 6, 1939. Convalescence was uneventful until the sixth postoperative day, when the abdomen became distended and the patient appeared clin.
ically to have peritonitis. The temperature rose to 103.4 F. X-ray treatments were started, with one treatment given on the sixth postoperative day, two on the seventh and one on the eighth. The suction apparatus was used at the same time. No sulfanilamide was given. Symptoms had fully subsided by the end of the ninth day, and convalescence from then on was uneventful (Fig. 74). She was dismissed from the hospital the twelfth postoperative day.

From the distention and the elevation of temperature one may be justified in making a diagnosis of peritonitis, although this could not be proved in this case. If the patient had received x-ray treatments immediately after the operation for three or four days, and if no complications had developed, it would have been impossible to credit x-rays with prevention of the complications. However, she did have a definite intestinal complaint which responded promptly to the combined use of the suction apparatus and x-rays. The use of these two simple measures, which often seem to work well together, is recommended in similar cases.

**Nonunion of Incisions**

The hypoproteinemia incident to the nonunion of abdominal incisions should be investigated by those who are eager to blame x-rays for this unfortunate complication.

We feel certain that the doses of x-rays given for acute infections in the abdomen never give rise to this complication. In fact, these small doses cause no reactions or sequelae of any kind. However, let us emphasize again that we have no reason to suspect that any tissue is immune to radiation necrosis following overdosage with x-rays, and we believe that in justice to the patient the ordinary precaution against radiation necrosis should be taken. Therefore, some filter and one's best judgment should be employed. The filter tends to protect the patient against accidental over-irradiation and, as far as we know, does not prevent the patient from receiving full benefit of the radiation given. This opinion has the support of observations in experimental animals.

We have long believed that heavy dosage of x-rays, a full erythema dose and more, started immediately after operation might interfere with union of the incision, and we make it a practice not to start postoperative therapy after removal of a
neoplasm until five or more days have elapsed. The small doses, with less than a full erythema total, used for the treatment of infections have, however, been definitely harmless in our hands.

**Analysis of Our Results**

The clinical impression we gained from treating acute peritonitis in its various stages during the past few years is that we were accomplishing some real good; but one cannot be certain about such matters until cases treated by various methods are grouped for comparison.

Our data are the result of examination of all cases listed in the records of Creighton Memorial St. Joseph’s Hospital (the results of the survey at St. Catherine’s and the Mercy Hospital are not yet completed) as peritonitis and appendicitis treated in that institution from 1934 to 1940. The hospital charts of 3,579 patients were examined; 290 had peritonitis in some form. These 290 cases were divided into three main groups:

1. Forty-nine cases of peritonitis localized in the region of the appendix without abscess formation. All patients recovered regardless of what treatment they received in addition to surgery.

2. Thirty-nine cases of peritonitis localized to the region of the appendix with abscess formation. Three patients died of pneumonia. The others recovered or developed general peritonitis.

3. Two hundred and two cases of general peritonitis with or without abscess formation. In this group there were 100 deaths. The high mortality rate, 49.5 per cent, made this group suitable for a study of the different methods of treatment used in addition to surgery. The following combinations of methods were considered (Table 24):

   a) Surgery supported by other general measures but without x-rays or the sulfonamides. By general measures is meant the suction apparatus and other means of intestinal intubation, oxygen tent, transfusions, etc. There were 109 cases and 71 deaths, giving a mortality of 65.1 per cent.

   b) The sulfonamides and surgery with other general measures. There were 42 cases and 16 deaths, giving a mortality of 38 per cent.

   c) Combination of x-ray therapy, the sulfonamides and sur-
Roentgen Treatment of Infections

gery with other general measures. There were 21 cases and seven deaths, giving a mortality of 33.3 per cent.

d) X-rays as an aid to surgery and other general measures. There were 30 cases in this group and six deaths, giving a mortality of 20 per cent.

TABLE 24
TREATMENT OF GENERAL PERITONITIS AFTER APPENDICITIS

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